REMARKS

This is in response to the Office Action dated August 26, 2003. Claims 1-8 are pending.

Applicant notes with appreciation the Examiner's allowance of claim 2, and the Examiner's indication that claim 6 contains allowable subject matter.

Drawing Objection

The drawings stand object to in paragraph 2 of the Office Action. The Office Action contends that "reference characters 10 and 11 have been used to wrongly designate a silicon oxide film and a second insulating layer, respectively." This drawing objection is respectfully traversed for at least the following reasons.

In Fig. 5D of the instant application, reference numeral 10 refers to the silicon oxide film formed in Fig. 5C, whereas reference numeral 11 refers to the thermal oxidation film formed due to heat treatment. There are different. Thus, it the use of reference numerals 10 and 11 in Fig. 5D is entirely appropriate, and the drawing objection should be withdrawn.

General

For purposes of example and without limitation, certain embodiments of this invention relate to a method of making a nonvolatile semiconductor memory including at least one memory cell. Figs. 3C and 4C illustrate an example memory cell including a tunnel oxide film 2 (i.e., an insulator including at least some oxygen), a floating gate 3, a first insulating film 7 (e.g., ONO, or any other suitable insulator), a control gate 8, and an

overlying second insulating film 10. A relevant aspect of certain example embodiments of this invention is shown in Figs. 5A-5D, and relates to processing of the tunnel oxide film 2 after the source/drain regions 4, 5 have been formed.

In particular, after the source/drain regions 4, 5 have been formed (e.g., by ion implantation) using material of the floating gate 3 as a mask, the control gate 8 is formed. Thereafter, as shown in Fig. 5B, ***after*** the source/drain regions and the control gate have been formed, isotropic etching is used to remove part of the tunnel oxide film 2 under a sidewall of the floating gate 3 (e.g., pg. 17, lines 6-18; and pg. 21, lines 11-16). Due to this removal of the damaged part of the tunnel oxide film 2, there is less of a path for electrons to leak from the floating gate 3 to the substrate 1 during operation of the finished product (e.g., pg. 21, lines 17-19). After part of the tunnel oxide film 2 has been removed as shown in Fig. 5B, a second insulating film 10 is formed. Then, a thermal oxidation process is performed as shown in Fig. 5D in order to oxidize sidewalls of the gate 3 thereby forming oxide layer 11. Due to the steps performed in Figs. 5B-5D, substantially uniform oxidation occurs at the interface between the floating gate 3 and the surrounding insulating films; therefore, substantially equal FN (Fowler-Nordheim) currents flow through the tunnel oxide film 2 during write operations (e.g., pg. 21, line 19 to pg. 22, line 2). As a result, variation in threshold voltage compared to conventional memories can be reduced, write time can be shortened, and/or cells affected by gate disturbance can be reduced (e.g., pg. 22, lines 2-11).

Claim 1

Claim 1 stands rejected under 35 U.S.C. Section 102(b) as being allegedly anticipated by Chen. This Section 102(b) rejection is respectfully traversed for at least the following reasons.

Claim 1 requires "***after*** said forming of the source/drain region, removing a portion of the tunnel oxide film immediately ***under*** part of the floating gate by isotropical etching; and depositing a second insulating film on the control gate, sidewalls of the first insulating film, the floating gate and the tunnel oxide film to be covered with the second insulating film." For example, see Figs. 4-5 which illustrate tunnel oxide film 2, floating gate 3, control gate 8 and source/drain 9. ***After*** formation of the S/D 9, Figs. 5A-5B illustrate that a portion of the tunnel oxide film 2 is removed immediately under part of the floating gate 3 by etching.

Due to this removal of a potentially damaged part of the tunnel oxide film 2, there is less of a path for electrons to leak from the floating gate 3 to the substrate 1 during operation of the finished product (e.g., pg. 21, lines 17-19). After part of the tunnel oxide film 2 has been removed as shown in Fig. 5B, a second insulating film 10 may be formed. Then, a thermal oxidation process may be performed as shown in Fig. 5D in order to oxidize sidewalls of the gate 3 thereby forming oxide layer 11. Accordingly, substantially uniform oxidation may occur at the interface between the floating gate 3 and the surrounding insulating films; therefore, substantially equal FN (Fowler-Nordheim) currents flow through the tunnel oxide film 2 during write operations (e.g., pg. 21, line 19

to pg. 22, line 2). As a result, variation in threshold voltage compared to conventional memories can be reduced, write time can be shortened, and/or cells affected by gate disturbance can be reduced (e.g., pg. 22, lines 2-11).

Chen has been misinterpreted by the Examiner. In particular, Chen clearly fails to disclose or suggest the aforesaid "after" aspect of claim 1. Figs. 4 and 6 of Chen clearly illustrate, in flowchart form, that in Chen the etching of the tunnel oxide is performed in step 454 *before* the source and drain are formed in step 456 (not "after" as required by claim 1). See also Chen at col. 6, lines 50-56. Moreover, Chen clearly shows that the etching of the tunnel oxide is performed in Fig. 4A using resist 710, and thereafter the S/D is formed in Figs. 4B-4D (col. 6, lines 36-42; col 7, lines 43-58). Thus, Chen clearly fails to disclose or suggest the aforesaid underlined "after" aspect of claim 1. Furthermore, it can be seen that Chen teaches directly away from the invention of claim 1 for the aforesaid reasons. Moreover, one of ordinary skill in the art would never have modified Chen to meet claim 1, because to do so would destroy the purpose sought by Chen's process.

Claim 5

Claim 5 requires "**after** said forming of the source/drain region and **after** the floating gate has been formed via the first conductive layer, removing a portion of the tunnel oxide film immediately under part of the floating gate by etching . . ." Again, Chen fails to disclose or suggest this aspect of claim 5.

Conclusion

For at least the foregoing reasons, it is respectfully requested that all rejections be withdrawn. All claims are in condition for allowance. If any minor matter remains to be resolved, the Examiner is invited to telephone the undersigned with regard to the same.

Respectfully submitted,

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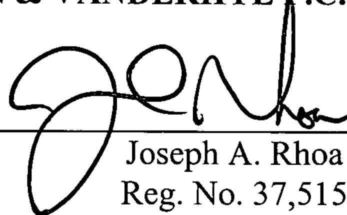
By: 

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